**Title** : Spin defects in atomically thin semiconductors

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**Research Area**: 2D materials, semiconductor physics

**Methods**: photoluminescence, scanning tunneling microscopy, spin resonance.

One of the most active research areas in condensed matter physics today focuses on the **electronic and optical properties of atomically thin semiconductors**, a field that rapidly emerged following the discovery of graphene in 2004. In recent years, studies have largely concentrated on the intrinsic excitonic properties of monolayers such as $MoS_2$ and $WSe_2$[1], which display remarkable light–matter coupling and rich excitonic physics[2].

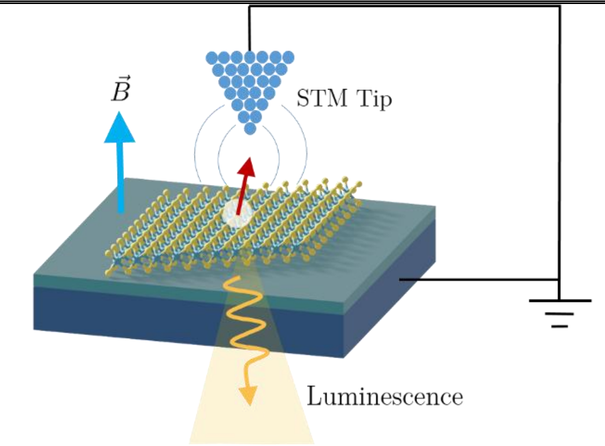
More recently, **individual defects** in these materials have attracted considerable attention because they can act as **single-photon emitters**[3,4], enabling the **precise localization of optical centers within a single atomic layer**. A key open question for quantum applications is whether such defects can host **optically addressable spin states,** similar to NV centers in diamond but this time embedded within a 2D surface.

Very recently, it has been demonstrated that **thin layers of germanium disulfide ($GeS_2$)**, after **thermal annealing**, exhibit **spin-defect-related emission** that remains **detectable at room temperature** [5]. Owing to the atomic-scale thickness of these materials and the **extreme sensitivity of spin defects to local electromagnetic fields, temperature, and strain**, they hold great promise for **quantum sensing applications** that operate in close proximity to the target system.

In this project, the intern will:

- **Fabricate 2D materials** from bulk crystals using our mechanical exfoliation setup,
- **Create spin defects** with controlled density through **high-temperature annealing**, and
- **Characterize their spin properties** at room and cryogenic temperatures under different conditions by using optical detection of spin resonance (ODMR).

The ultimate goal is to isolate **single spin defects** and **demonstrate long spin coherence times**. This project is an **experimental** one, and is ideally suited for a student with an interest in **fundamental semiconductor physics**, **2D materials**, and **quantum technologies**. This internship can be continued as a Ph.D. project that will involve the characterization and manipulation of these defects with a novel approach based on a scanning tunneling microscope. The experimental setup, illustrated in the figure below, is developed and supported by the **ERC Starting Grant 101075855 (OneSPIN)**




A scanning tunneling microscope (STM) is used to study the local environment and the spin properties of single defects in 2D materials. A localized electron spin (red arrow) is excited by a laser and undergoes coherent precession under the influence of both a static and a radiofrequency magnetic field. The optical detection of this single spin resonance is achieved by analyzing the photoluminescence (yellow arrow) as a function of the frequency of the driving field. The exact shape of the resonance curve is expected to be highly dependent on the spin's atomic and electric environment.

**References**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